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Running Head: Innovation in Cultural Contexts

Technology-Supported Learning Innovation in Cultural Contexts

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Abstract

Many reform initiatives adopt a reductionist approach to cultural change, assuming that deep changes can be realized by introducing new curriculum and textbooks, technological tools, and classroom activities. This article elaborates a complex system perspective of learning culture. A learning culture as a complex system involves macro-level properties (e.g., epistemological beliefs, social values, power structures) and micro-level features (e.g., technology, classroom activities). The macro-level properties have significant downward causations to the component features, leading to the fact that new technologies and activities are often assimilated into existing practice without deep change. Deep changes in macro-level properties are the emergent result of interactions among component parts of a learning culture, and cannot be reduced to any component. This complex system approach is applied to examining technology-supported educational change in East Asia. A case-based analysis is then provided, looking at how teachers sustain the knowledge building innovation in different contexts. Deep and sustainable learning innovation needs to address issues at the macro- and the micro-level, and engage teachers in deepening the underlying principles, evolving designs in local contexts, and pursuing reflective improvement.

Keywords: Learning culture, Learning innovation, Technology, Emergentism, Complex system

Introduction: Two Phenomena to Be Explained

Reforming education systems to address the knowledge society challenge is of global interests (UNESCO, 2005). Researchers from around the world have been exploring new learning designs—often supported by new technologies—that can help increase student capabilities of productive and collaborative knowledge work (e.g., Edelson, Gordin, & Pea, 1999; Krajcik, Blumenfeld, Marx, Bass, & Fredricks, 1998; Linn & Slotta, 2000; Paavola, Lipponen, & Hakkarainen, 2002; Scardamalia & Bereiter, 2006; van Aalst & Chan, 2007; van Joolingen & de Jong, 2007). These learning innovations involve new learning activities (e.g., inquiry, group work), curriculum resources, and technology tools. For many of them, the ultimate goal is to change the traditional learning cultures (see also, Bielaczyc, 2006; Bielaczec & Collins, 1999).

This article speculates on technology-supported learning innovation in specific cultural contexts. I'm particularly interested in understanding the complex nature of learning culture and explaining two disturbing phenomena. The first phenomenon pertains to the adoption of technology in different cultures. There are growing interests in using new technologies as an agent of cultural change in education (Girod & Cavanaugh, 2001; Price & Oliver, 2007). However, educational practitioners in a culture tend to choose "domesticated technologies" (Salomon & Almog, 1998) that do not affect life in classroom much, and use them in culturally familiar ways. In doing so, they reject the opportunities of significant cultural change (Zhang, 2007). Why is it so hard for new technologies to play out their role as an agent of change?

The second phenomenon, which is more at the classroom level, is the "lethal mutation" of learning innovations during implementation (Brown & Campione, 1996). When implemented in classrooms, many innovation programs tend to be ritualized as surface activities and procedures, for example, choosing an inquiry topic or task, collecting information, doing experiments, presenting results, etc. These classroom activities and procedures are regarded as the means to enabling deep change in the learning culture. But often times, there is no deep change evident after the proposed learning activities have been carried out. Why?

The above two phenomena have been discussed as two separate issues. But actually they are deeply connected. Both are associated with a core issue in our field: How should we conceptualize a learning culture and the nature of its change? This paper reflects on this core issue, and elaborates a complex system perspective on learning culture. This approach is applied to examining technology-supported educational change in East Asia that has a distinctive learning culture. A case-based analysis is then provided, looking at how an international network of teachers pursued deep change using the knowledge building pedagogy and technology (Scardamalia & Bereiter, 2006), one of the foremost innovations to address the knowledge society challenge.

Reflecting on the Reductionist Approach to Learning and Technology Research

In earlier research on technology in education, a large number of studies searched for media effects—whether one medium is better than another in causing effective learning. A conclusion is that comparing the effects of different media is not a productive question for research, because media effects can never be separated from method effects—effects of instructional designs (Kozma, 1994).

Intersecting with research on media effects are the investigations of the role of technology in educational change. A critical look at the literature on this topic unveils that researchers ask a similar question as media effects, but focusing on technology's impacts on the practices of teachers and schools: Can new technology cause changes towards innovative, constructivist pedagogical practice or classroom culture? There are studies on both sides showing that using new technologies causes constructivist practices (e.g., Becker & Ravitz, 1999), or technology does not affect teaching practice (e.g., Cuban, Kirkpatrick, & Peck, 2001). A middle-way stance on this issue suggests that technology can be a catalyst of pedagogical change, but does not cause change by itself (e.g., Lin & Hatano, 2003; Salamon & Perkins, 1996). The influence of technology is mediated in substantial ways by teachers' interconnected beliefs about learners, teaching, and the role of technology within a school context (Windschitl & Sahl, 2002).

Despite of the variations in research focuses and contexts, the above two lines of research on technology impacts share the same limitation in problem formulation and underlying beliefs about causality, which are characteristic of a reductionist, analytic approach. This approach assumes that complex phenomena can be explained completely in terms of other, more fundamental phenomena. Learning culture and teaching practices taking place in it are conceived as a resultant entity, on which new technology and learning designs are created to have an impact. Deep learning goals and target learning cultures are reduced to a list of things to do and to use: tasks, activities, procedures, resources, tools, etc. Common to traditional and many modern models of teaching (e.g., project work, WebQuests), tasks and activities—instead of big ideas—become the

center of classroom practice (Scardamalia & Bereiter, 1991). Thus we are puzzled when no deep change takes place after the things on the "to do list" have been done; and when new technologies, which are conceived as an agent of change, fail to cause change in the traditional learning culture and are instead domesticated by it. Researchers are often blamed that the new learning models they developed are not specific enough (Black & William, 1998). Teachers and schools are blamed that they have not implemented the new learning models with high fidelity (Boddily, 1998). Beyond the above reasons, we need to reflect on the fundamental framework we have used to understand learning culture and its change. Put it briefly, we should appreciate that a learning culture as a complex system is more than the sum of its components (e.g., activities, tools).

Towards a Complex System Perspective of Learning Culture

This paper elaborates a complex system perspective on learning culture. A complex system is a system composed of interacting parts that as a whole exhibit one or more properties not assumed by any of the individual parts. Complex systems pervade the nature and our human society. Examples include ant colonies, climate, brain, stock markets, and so on. These complex systems are characterized by multilevel organization, multiple interactions between many heterogeneous components, and dynamic, often invisible processes that constantly evolve and unfold over time (Arthur, 1999; Hmelo-Silver & Azevedo, 2006). An important concept in the complex systems literature is *emergence*, which refers to the way system-level properties arise out of multiple, relatively simple interactions among the component parts (O'Connor, 1994). For example, human consciousness is an emergent property grounded in and arising from interactions among brain cells. It is a system-level quality that is not assumed by any of the cells, thus cannot be reduced to biological and chemical processes.

The research of complex systems has led to refreshed interests in and deeper inquiries of emergentism, a school of philosophical thinking started by several British philosophers (e.g., Morgan, 1923). Emergentism has important implications to research of human social practices such as education. A social organization or practice is a dynamic, complex system that has many component parts as well as system-level properties. There are dynamic interactions between micro-level components and macro-level properties. The micro-macro dynamics involve two types of causations: *Supervenient causations* refer to the bottom-up emergence of more complex, "higher level" properties from the organization and interaction of simpler, "lower level" component parts; *Downward causations* represent the significant influence of the overall system organization on the function of any component (Kim, 2006; Sawyer, 2003).

The complex system perspective, emergentism in particular, provides a productive framework for studying learning cultures and their changes. Although the term of "learning culture" (or "classroom culture," "pedagogical culture") has been widely and increasingly used in publications, it has rarely been explicitly defined. In this article, when the term of "learning culture" is used, it refers to historically-rooted cultural attributes related to learning and education carried by an identifiable community (e.g., a nation, a regional community, a school community). These cultural attributes are reflected as collective, intuitive understanding of what learning is about and how it should be approached in practice, as well the language, tools, social norms that mediate learning and teaching practices. A wide range of phrases have been used in the literature to characterize learning cultures: beliefs about knowledge and learning, learning orientations, power structures in classroom, social organization of learning, valued learning outcomes, knowledge content, learning

strategies and activities, technology integration, time and spatial configurations, etc. (e.g., Bielaczyc, 2006; Little, 1990; Tweed & Lehman, 2002). Taking a complex system perspective, a learning culture can be considered as a complex, social practice system that involves multiple component parts. It is important to differentiate macro-level properties of a learning culture from specific, micro-level characteristics associated with particular components. Macro-level properties characterize a learning culture as a whole. They are not as tangible as classroom activities, resources, and tools; but are essential across contexts and facets of the educational practice in a community. Some of the phrases noted above are at this level. I summarize them as the following core properties:

(a) Epistemologies-in-practice: These refer to epistemological beliefs about knowledge, learning, and teaching deeply held and intuitively enacted by an educational community. One of the core dimensions is the continuum from an objectivist to a constructivist epistemology. Recent reform programs are dedicated to transforming classroom practices towards the constructivist end, with students engaging in active meaning-making, critical thinking, and creative knowledge construction in socially situated contexts of learning (Bransford, Brown, & Cocking, 1999). Students as knowledge builders are not finding the single true answer, but working on powerful ideas (e.g., theories, explanations, models) and pursuing continual idea improvement (Bereiter, 2002).

(b) Social values applied to learning and education: These relate to the questions of what characterize the "educated person" in a particular culture (Levinson, Foley, & Holland, 1996), what kinds of intrinsic learning outcomes and associated extrinsic benefits are highly valued by a society or community. Is creativity more important than obeying the social norms? Are individual achievements more rewarded than contributing to the collective good? Are external incentives (e.g., moving to a higher social status) more important than intrinsic incentives (e.g., learning for the sake of learning)?

(c) Power structures in educational practice: In cultural studies, a key factor related to power structures is power distance, which refers to the extent to which members of a society accept that power in institutions and organizations is distributed unequally. "People in large power distance societies accept a hierarchical order in which everybody has a place which needs not further justification. People in small power distance societies strive for power equalization and demand justification for power inequalities." (Hofstede, 1983, p.83). A core relationship in educational practice is the relationship between the teacher and students. Recent innovation programs pursue a shift from a teacher-centered, authoritative classroom structure toward a democratic structure of participation (Bielaczyc & Collins, 1999).

A contemporary learning culture involves a number of major components: curriculum guidelines; learning tasks, activities and procedures; learning resources and technologies; assessments of learning; institutional organization of schooling. Micro-level properties associated with these component parts in a learning culture reflect as: What kinds of knowledge content is taught and how is it organized and sequenced? What kinds of learning strategies and activities are conducted? What technologies are used? How is the classroom spatially organized? Recent education reforms have been primarily addressing changes in the components, expecting that deep change in classroom culture can be enabled by introducing new curriculum standards and textbooks, learning tasks and activities, and technologies. Even though some reform programs recognize the

importance of introducing new teaching beliefs in schools, they lack effective strategies to address belief change, which cannot be "designed" and handed over to teachers.

According to emergentism, macro-level properties are as real as micro-level components, and these two levels interact with each other in a significant manner. The effects of micro-components (e.g. technology use, classroom activities) on the high-level properties of a learning culture should be understood as *supervenient causations*. Such causations are analogical to chemical effects instead of mechanical effects. It is the interactions of multiple component entities that give rise to new macro-level properties of a culture. The evolution of a pedagogical culture is the emergent result of the interactions of its components. This evolution cannot be fully predicted, and may not be attributed to any one of the components in a reductionist way.

On the other hand, the macro-level properties of a learning culture also have significant downward causal influences on its components. A learning culture as a whole shapes the needs for technologies as well as the way educators understand and use technologies. This leads to the fact that educators often choose "domesticated technologies" that is consistent with their exiting culture, hence do not affect life in the classroom much (Salomon & Almog, 1998). Similarly, when incorporating new classroom processes and activities, teachers tend to reinterpret the processes and activities in light of their beliefs and conceptions about learning and teaching, and adjust the processes and activities to fit into existing classroom structures. By assimilating domesticated technologies and culturally compliant teaching activities, an existing teacher-centered classroom culture can be maintained, avoiding deep conflicts with the incorporated technologies (e.g., computers) and strategies (e.g., cooperative learning).

The above complex system perspective, macro-micro dynamics in particular, provides an explanatory framework for understanding the two disturbing phenomena identified in the beginning of this article: The difficulty of using technology as agent of cultural change and the risk of lethal mutation of learning innovations in implementation. The widely observed phenomena of using new technologies, activities, and resources to support a traditional learning culture without deep change can be further explained using an important concept in the emergentist literature: "*multiple realizability*" of a complex system. This concept indicates that a macro-level property can be realized through multiple mechanisms at the component level (Fodor, 1974; Sawyer, 2003). A teacher-centered authoritative power structure can be maintained whether it is in a chalk-and-board or an online and multimedia environment, whether students are attending lectures or doing hands-on work, whether they are learning individually or in small groups.

To further elaborate the complex system perspective, I will use this framework to analyze two examples. Regarding the difficulty of using technology as agent of cultural change, I will discuss the use of technology in the cultural contexts of East Asia. Focusing on strategies to avoid lethal mutation of learning innovations, I will discuss the implementation of the knowledge building pedagogy and technology.

How Does the Eastern Learning Culture Shape Technology Use?

The Eastern culture is rooted in the tradition of Confucianism; while the Western culture is rooted in that of Socratic philosophy. The distinction between the West and East is certainly too simplistic. However, this article sticks to these terms for the purpose of convenience.

Macro-Properties of the Eastern Learning Culture

In terms of epistemological beliefs, Easterners hold a more authoritative view of knowledge and learning, assuming that intellectual elites create knowledge and define moral principles, which are interpreted and communicated to the public by scholars, and to students by teachers. Cross-cultural comparisons revealed important differences in beliefs about learning (see Tweed & Lehman, 2002). Comparing to their Western counterparts, Chinese students and instructors are more likely to treat texts and the instructor as highly authoritative sources of knowledge, expecting the instructor to provide more structure and guidance. Learners prefer to first understand knowledge from these sources, and postpone their questioning and commenting. While Western students and educators tend to attach greater importance early in the learning process to questioning and criticizing information presented by an instructor (Pratt & Wong, 1999). Eastern students focusing on knowledge acquisition should not be simply interpreted as passive rote learning. Instead, they value active, effortful, and reflective learning. Self-engagement and reflection are conceived as core qualities of a good student (Jin & Cortazzi, 1998; Stevenson, Chen, & Lee, 1993; Tweed & Lehman, 2002). Qualified teachers often model effortful, reflective learning behaviors; stimulate learners' thinking and reflection by asking thought-provoking questions; and design and use informative assignments to promote flexible understanding of knowledge (see also, Lee, Liu, & Lee, 2003; Stevenson & Stigler, 1992).

In terms of social values, Easterners value collective good over individual interests. They seek harmony, order and well-being in a society by emphasizing social obligations of individuals and classes, who should behave in line with the social expectations of their social roles (Huang, 2002). In education, this collectivist thinking gives more weight to social norms (Li, 1996), and urges students to acquire socially recognized essential knowledge and moral principles, and transform their own thinking and behaviors accordingly (Tweed & Lehman, 2002; Zhang, 2007). In a study, Jin and Cortazzi (1998) compared the responses of Chinese and British students on a variety of attitudinal items. When asked what constitutes good teaching, Chinese students were more likely than British students to define a good teacher as someone with deep knowledge who sets a good example and teaches students about life. British students were significantly more likely to define a good teacher as someone who is helpful, sympathetic to individual students, and who arouses their interest and organizes a variety of classroom activities. The collectivist culture is also associated with a pragmatic orientation to learning. Eastern learners are more likely to see education as a means to achieving practical goals, for example, to pass competitive exams, to gain social recognition, to secure a job of civic service, or to pursue a higher social status (Tweed & Lehman, 2002).

In terms of power structures, people in the Eastern societies generally accept larger power distance (Bond & Hwang, 1990). Individuals of all social classes are urged to fulfill the requirements of their social roles. In educational contexts, greater emphasis is placed on strictness and discipline, and less emphasis is placed on children's independence and creativity (Ho & Kang, 1984). Students should show full respects to their teachers, who are considered authoritative professionals. Studies suggested that Chinese students were more respectful of their teachers than British and Australian students (Aldridge & Fraser, 2000; Jin & Cortazzi, 1998). The social organization of schooling in the Eastern culture is also more centralized. Central governments design and execute policies and standards for school finance, curriculum, textbooks, assessment, and teacher

preparation. A current direction in educational reforms is to decentralize the educational systems and turn over more control to local authorities and schools.

Downwards Causations of the Macro-Level Properties on Technology Use

As noted above, the Eastern culture holds a more authoritative view towards knowledge and learning, a more teacher-dominated classroom structure, and a stronger focus on essential knowledge and moral principles, valuing social norms. Facing the challenge of a knowledge society, the East Asian nations are determined to move towards a more democratic and creative learning culture. They look upon information technologies as a revolutionary tool to help achieve this goal (Hung & Chen, 2003; Mizukoshi, Kim & Lee, 2000; Ziguras, 2001). For example, China launched the "Connecting-Every-School" project in 2000 as a part of its Quality Education initiative (Zhang, 2007). The development of new technologies is integrated with the comprehensive reform of the national curriculum. Although computers and the Internet are increasingly used in schools, the expected transformative impacts of new technologies on educational change are far from becoming evident. The new technologies are mostly assimilated into existing classroom structures to support teacher-dominated, group-based knowledge acquisition (Zhang, 2007).

The Eastern epistemological beliefs, social values, and power structures in education have a deep impact on educators' needs and choices of learning software and hardware, as well as the methods of using these tools in classroom. As a result, teachers prefer content-bound and curriculum-compliant courseware and resources, including tutorials, drills-and-practices, computer-assisted tests, and Web-based gateways that sort learning resources in line with the national curriculum (Zhang, 2002, 2007). In contrast, in the Western learning culture that is more learner-centered, activity-focused, and individualized, technology is more likely to be used as content-open productivity tools (e.g. word processing, simulations, explorative environments, graphics, spreadsheet, database, presentation) (Becker, Ravitz, & Wong, 1999). In East Asian schools, there is also a strong need of digital projectors or LCD display boards. An international study showed that Hong Kong had a much higher ratio of schools with digital projectors or LCD display boards than many Western countries (Law, Yuen, Ki, Li, & Lee, 1999). These software and hardware resources that are of Eastern teachers' preferences can help them to deliver demonstrations and lectures in large classes without significant changes in the teacher's role. Even though exploratory learning tools are sometimes adopted, they are often used to aid teachers' demonstration and lecturing. An example is the Geometry SketchPad, a discovery-oriented tool for geometry learning designed in the US. This software has been widely adopted by teachers in China, but mostly as a teaching tool to help create vivid demonstrations (examples in Chinese are available at http://www.gspinchina.com).

Another example of the downward causations of the Eastern culture on technology use is the adaptation of distance learning in higher education. Distance learning was invented in UK as a bond of learning approach and technology rooted in the conception of self-paced and open learning. Since it was imported to East Asia, distance learning has been adapted in many aspects. Unlike the individualized, self-paced learning adopted by institutions in UK and other Western nations, distance learning in China has been localized as group-based distance lecturing (see also, Tu & Twu, 2002; Zhu, Gu, & Wang, 2003), which organizes learners into classes to attend lectures at local learning centers. These lectures are delivered through television, VCDs/DVDs,

satellite-based digital video broadcasting, videoconferencing systems, or Internet-based video/audio streams synchronized with PowerPoint slides. Contrary to the expectation that Chinese instructors may not be able to lecture and dominate learning any more in a Web-based environment (Lee, 2004), they naturally extend group-based lecturing into the virtual world. Interestingly, Eastern learners also favor this approach. In our recent survey among distance learners in undergraduate and graduate programs, a majority of learners stressed the importance of studying together with their classmates in a classroom and interacting intensively with the instructor (Zhang, Wu, & Li, 2003). This result is consistent with observations of students in Korea (Jung, 2000) and South East Asia (e.g., Malaysia) (Ziguras, 2001). It is almost impossible to identify who first made the above adaptations and reinventions of distance learning; they seemed to have emerged from a collective process in which designers, instructors, and students all played important parts.

As the above analyses revealed, the epistemological beliefs, social values, and power structures central to the Eastern learning culture shape the emergent needs, selection, understanding, design, and use of technology. This downward influence is realized through educators' efforts to build deep connections between new technologies and ongoing educational practices in their local contexts, fostering the historical descending of their learning culture. A new technology only has its meaning potentials; its meaning needs to be actualized and contextualized by members of a community. By adapting technology to their local contexts, teachers connect technology to their pedagogical beliefs, social values, and activity patterns, and eventually achieve a dynamic fit with the contexts. This process contributes to the continuity of a learning culture, but also cultural resistance to deep change. Learning technology is so deeply embedded in cultural contexts, thus cannot be imported from one culture to another in a simplistic way.

Working with the Macro-Micro Dynamics to Enable Deep Change

A complex system perspective suggests the importance of addressing the macro-micro dynamics. To pursue deep and sustainable change, teachers in an innovation program need to work with both macro-level properties and component features of their learning culture, and pursue deep reflections across these two levels. Component features, for example, new classroom activities and technologies, are more tangible and easier to approach. But implementing these components may not necessarily enable deep change in macro-level, core properties of the traditional learning culture—the governing epistemological beliefs, social values, and power structures. Learning innovations seeking deep and sustainable change need to directly work with these core cultural properties. Transformations in these aspects are difficult to achieve. As research on teacher education indicates, there is an important distinction between teachers' espoused theory and their "theory-in-use"—what they actually do (Argyris & Schon, 1974). Acquainting teachers with new, explicit theories and principles of learning often only affects their espoused theory. A way to help bridge teachers' espoused theory and "theory-in-use" is to engage them in deliberate reflection on their practice and underpinning beliefs.

An important contribution made by learning scientists to the research of deep and sustainable change is the concept of principle-based innovation (Brown & Campione, 1996). It refers to new learning programs defined based on thumb principles of learning and teaching, as opposed to procedure-based innovations defined based on activity structures and procedures. Many technology-supported learning innovations developed by researchers and governmental agencies

draw on a proceduralized approach. An innovation program of this category typically includes a technology package providing technological tools and resources and an activity package specifying the learning procedures and activities (e.g., pre-designed projects). Teachers are seen as "users" who implement these tools and activities in their classrooms with high fidelity (see also, Barab & Luehmann, 2003; Penuel & Means, 2004). In a principle-based learning innovation, teachers design and re-design their classroom processes in light of the thumb principles, instead of simply implementing the provided classroom activities and technological tools. Below presents my recent analyses of the implementation of the knowledge building pedagogy and technology (Scardamalia & Bereiter, 2006), a principle-based innovation seeking to transform classrooms into knowledge building communities.

The goal of the knowledge building pedagogy is to prepare students for a knowledge-based society in which knowledge creation pervades. In a knowledge building community, students contribute their ideas as public, conceptual artifacts, which are continually revisited, critically examined, applied, revised, re-organized, and risen above towards higher levels of conceptualizations and deeper understandings (Scardamalia & Bereiter, 2006). Knowledge building in classroom is guided by a set of 12 principles (Scardamalia, 2002), several of which address issues related to epistemological beliefs, social values, and power structures underpinning educational practices. For example, the principle of *improvable ideas* indicates that all ideas should be treated as ever improvable. Students work continuously to improve the quality, coherence, and utility of ideas, instead of finding out a single true answer. For idea improvement to prosper, the classroom culture must encourage participants to take risks—revealing ignorance, voicing half-baked notions, giving and receiving criticism. *Collective responsibility for community knowledge* points to the importance of contributing to the collective knowledge enterprise of the community, with students working as a team to continually improve their ideas, not simply advance their own. *Epistemic agency* highlights the need to turn over high-level control of knowledge work to students, dealing with problems of goals, motivation, evaluation, and long-range planning—problems that are normally left to teachers. There are several principles at a more specific level, informing but not specifying classroom activities. These include: *authentic problems and real ideas, knowledge building discourse, constructive uses of authoritative sources, embedded and transformative assessment*, etc. The knowledge building process is further supported by Knowledge Forum®, a computer-based collaborative knowledge-building environment (Scardamalia, 2004). Knowledge Forum provides a communal space where students can share their understanding and work together to continually improve the ideas represented there.

Implementing a principle-based innovation like the knowledge building pedagogy and technology poses great demands on teachers. Can teachers productively work with the core principles and develop effective designs in classroom? How? A part of my recent research has been focusing on identifying strategies for enabling and sustaining the knowledge building innovation (Zhang, Hong, Teo, Scardamalia, Morley, 2008; Zhang & Scardamalia, 2007). Additionally, I coordinated the Analyses, Reflections, and Tours event at the annual Knowledge Building/Knowledge Forum Summer Institute (http://ikit.org/summerinstitutes.html) aimed at creating partnerships between teachers and researchers. Teachers shared and elaborated their designs of knowledge building; researchers looked into their knowledge building processes and provided feedbacks using a set of analytic tools. A team of teachers from Canada, Finland, Hong Kong, and Spain has participated in this event. The above research and practical work helped to reveal significant efforts of the

teachers to sustain the knowledge building innovation in different school and cultural contexts. These efforts are elaborated below, focusing on how the teachers deal with the micro-macro dynamics.

(a) Deepening understanding of principles and evolving designs. Teachers think and re-think about macro-level, core issues related to their classroom culture (e.g., epistemologies, social values, and power relations) in light of the knowledge building principles, as they pursue effective classroom designs. For example, related to the principle of *epistemic agency*, the teachers deepen their understanding of what this principle really means and what level of agency can be enabled among a particular group of children. They experiment with strategies to turn over more control to students in classroom and in Knowledge Forum. Through reflective observations of students' knowledge building, they are often impressed by the level of thinking and work students are capable of. As a Kindergarten teacher commented: " *My soul gets constantly amazed by what these young children can accomplish..."* These observations increase their trust in student agency, and help them to envision new possibilities of having students take on more control over their knowledge building.

(b) Identifying and overcoming barriers to implementing the principles in specific contexts. The implementation of the knowledge building principles faces different practical conditions and barriers in different classroom settings and cultural contexts. Teachers need to understand the contexts, reflect on the barriers, and develop effective strategies accordingly. As noted earlier, students in the Eastern culture often expect the teacher to provide more guidance and structure, and give more weight to external, social value of learning (Tweed & Lehman, 2002). The teachers in Hong Kong found it challenging to engage their students in open-ended knowledge building discourse and critical thinking of ideas. To deal with this challenge, several teachers experimented with culturally adaptive strategies. For example, based on student engagement in online and face-to-face discussions, the teachers gave each student a participation score as a part of the final grade. They also set various awards to encourage question asking, idea improvement, critical comments, and so forth. These strategies are rarely used by Canadian teachers.

(c) Reflecting on key classroom issues in light of the principles. The teachers monitor and reflect on their classroom processes in light of the knowledge building principles: Are there idea improvements evident in conversations? Are students enacting collective responsibility for community knowledge? How can a teacher intervene in the knowledge building process without compromising students' epistemic agency? Critical reflections of this kind are especially important when unfavorable events occur. Through reflections, teachers can figure out reasons behind the problems and work out a plan to move the community onto a productive route. For example, a Grade 5/6 teacher in Toronto once found that some of the students showed resistance to using Knowledge Form. Through his observation and reflection, he realized that the students had been asked to use Knowledge Forum too much for things that were not necessary, for example, to write down factual information instead of important ideas. He reflected:

> *"So we have to really be careful of how we use the technology that is not for the sake of technology. It has to be for the sake of knowledge building. Some knowledge building happens in KB* talks*, some happens in notebooks, and some happens there [in Knowledge Forum]."*

Through the above efforts, the teachers deepen their understanding of the core principles; develop, reflect on, and improve classroom designs; and address emergent problem in specific contexts. They identify possibilities and strategies to implement the core principles, making knowledge building an ever-improving practice. These efforts are substantially augmented through the interactions in a teacher community that shares practices, engages critical professional discourse, and seeks continual improvement (Zhang et al., 2008). Working with both macro-level properties and component design features in a learning culture and building a dynamic flow between them are critical to deep classroom change.

Conclusions and Implications

This article elaborates a complex system perspective of learning culture and its change. A learning culture is a complex system of social practice. It involves macro-level properties (e.g., epistemological beliefs, social values, power structures) and micro-level features (e.g., curriculum and textbooks, technology, classroom activities, assessment). The macro-level properties of an existing culture have significant downward causations to the component features, leading to the historical descending of the core cultural properties. The downward causations explain why new technologies are assimilated into ongoing practice without causing deep change; and why new classroom activities and materials provided by reformers are often ritualized as surface procedures in classroom.

Deep changes in underpinning epistemological beliefs, social values, and power structures are the emergent result of interactions among component parts of a learning culture. These deep changes are unpredictable, and cannot be reduced to changes in component parts. Many modern reform initiatives adopt a reductionist approach to cultural change, assuming that deep changes can be naturally realized by introducing new curriculum and textbooks, technological tools, classroom activities, and assessment. The complex system perspective implies that deep and sustainable learning innovations need to address challenges associated with both the micro- and the macro-level. They need to endorse teachers' efforts to deepen the underlying principles, evolve new designs in their contexts, and engage in deep reflections across these two levels. On this sense, teachers are not merely users of innovations, but themselves grassroots innovators. Engaging teachers' innovative capacity and agency represent a challenge for both the Eastern and the Western societies, although the specific cultural contexts and barriers vary.

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